BENTON HARBOR POWER PLANT LIMNOLOGICAL STUDIES

PART V. WINTER OPERATIONS, MARCH 1970

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DIVE REPORT

Date: 10 March 1970

Location: Donald C. Cook Nuclear Plant site, Lake Michigan

Depth: 12 feet Visibility: 4-5 feet Bottom Time: 15 minutes

Wind Direction: NW Wind Speed: 10-15 knots

Sea Height: 2 to 3 feet Direction from: NW

Team: Robert F. Anderson and John Krezoski

Objective: Locate and recover glass plates from two periphyton collectors set last August in 15 and 30 feet of water on the range established by the two red and white barber poles north of the Cook plant site.

Report: Ice conditions at the dive site on 10 March 1970: Open water to horizon, areas of pack ice also visible on the horizon. Open pack ice drifting close to shore.

Work was conducted from a 16-foot aluminum boat. Soundings were taken to determine where to begin a search pattern for the periphyton collector located in 15 feet of water. Soundings in the area of the 15-foot depth contour revealed a depression with a depth of 19 feet. Since a lead line was used for sounding, it was impossible to determine whether this depression was the base of a shoal or the result of ice scour.

The dive plan was to start a search pattern at a depth of 12 feet and work out from this point. After positioning the boat on the range poles we made our descent on the anchor line and conducted a 100-foot circular search pattern using a sweep line. During our descent a strong current from the northwest was observed. Bottom type was a medium sand. Irregular ripple marks were observed on the bottom running parallel to the shoreline. Small amounts of organic detrital material had collected between the ripple

marks. Near the completion of our search pattern we approached a large piece of ice that was anchored to the bottom in 12 feet of water. A furrow in the bottom varying in depth from 6 inches to 1 foot was observed under the section of ice that was anchored to the bottom. The submerged area of this large piece of ice was tapered down to a point that was embedded in the sand.

Upon completion of the first dive weather conditions had become marginal for diving. It was decided to terminate diving operations.

Another attempt to recover the periphyton collectors and conduct a survey for the effects of ice scour is scheduled for the first part of April.

The west side of the lake was devoid of ice. There was little or no ice around the Zion plant site[20], the Oak Creek plant, Milwaukee, and the Port Washington plant.[21]

Sand in the ice.

The objective of this cruise was to try to obtain evidence as the means by which sand is incorporated into the ice. Of particular interest in this connection was the possibility that shore-ice blocks leaving shore during breakup might carry substantial amounts of sand on their undersides, and that overturning of the blocks during melting or fragmentation might expose to view sand layers of some thickness. Alternatively, waves breaking against an ice edge might throw sand onto the ice surface where it then became covered by more ice. We hear vaguely of "ball ice" that is reported to roll along the bottom; whether it exists we do not know, and the present study is unsuited to provide information on this matter.

In the present study we have seen no evidence indicative of ice-bottom carrying of sand. All the sand seen in shore ice or ice floes during this cruise was in thin strata incorporated in the ice. These strata were dense enough to impart a sand-color, but not so dense as to prevent the ice underneath from being seen. They could well have been formed by waves tossing suspended sand onto the shore ice. In fact on 18 March in front of the Cook plant there was a notch in the shore ice and a scattering of sand lay on the ice behind the notch.

We believe that this cruise has shown a widespread occurrence of the wave-tossed sand phenomena, for many ice floes showed scattered-sand strata as the surface ice melted, see Slides 4-10, 4-14, 5-3, 6-12, 6-15 and others. Wave-tossed sand in the top of the ice bluff is clearly evident in Slide 7-16, and sand above water in the lower part of the ice bluff is evident in Slides 2-20 and 2-21. These ice bluffs were still fast to shore and were being sectioned by melting at the face.

Guide to color slides.

1. Slide 1-16. Looking east towards Port Sheldon piers.

2. Slide 1-16, Slides 2-11, 2-12. Looking east at ice bluff south of Port Sheldon piers.

3. Slides 2-6, 2-8, 2-7. Looking east just north of Port Sheldon outfall, Port Sheldon outfall, just south of Port Sheldon outfall.

4. Slides 2-8, 2-7. Port Sheldon outfall, just south of Port Sheldon outfall.

5. Slides 2-21, 2-20, 2-16, 2-18. Ice bluff immediately south of Saugatuck piers.

6. Slides 1-18, 1-17. Sand on ice, inshore of bluff at Saugatuck.

7. Slide 3-6. Ice south of Saugatuck.

8. Slides 3-14, 3-13. Ice pack south of Saugatuck. Note sand.

9. Slides 3-9, 4-17, 3-16, 3-11, 4-19, 4-18, 4-11, 4-6, 4-16, 4-14, 4-9, 4-15, 4-10, 3-20. Ice pack south of Saugatuck. Note sand.

10. Slides 6-18, 6-20. Pancake ice southwest of South Haven. Note sand, raised rims.

11. Slides 6-13, 6-19. Ice pack southwest of South Haven.

12. Slides 6-14, 6-20. Southern part of ice pack. Slide 5-1. Northern part of ice pack, looking north.

13. Slides 5-2, 5-3, 6-4, 6-9, 6-10, 6-12, 6-15, 6-21. Ice southwest of South Haven. Note sand.

14. Slide 5-6. Ice off of Palisade plant site.

15. Slides 5-7, 7-5, 7-5. Ice bluff at Palisade plant site. Note sand; blow-hole on extreme right hand side of 7-3.

16. Slides 5-9, 7-8, 7-10. Ice at Cook plant site.

17. Slide 7-19. Shoreline west of Bailly plant outfall.

18. Slides 7-15, 7-16, 5-19. Ice and shoreline east of Bailly plant outfall.

19. Slide 5-19. Bailly outfall and fishing boats.

20. Slides 8-9, 8-8, 7-21. Zion plant site and shoreline immediately north.

21. Slides 8-15, 4-11. Oak Creek and Port Washington power plants. Note lack of ice.

Slide 46. Shore ice, consolidated offshore pack ice and unconsolidated pancake ice south of Manistique, Mich.

Slide 47. Ice condition around islands in northern Lake Michigan looking across northern tip of Beaver Island toward the east.

Slide 48. Consolidated ice in the Straits of Mackinaw looking northeastward from a point between Beaver Island and Little Traverse Bay.

Slide 49. Little Traverse Bay area near Petoskey, Mich., showing consolidated ice covering Bay area.

Slide 50. Lakeward edge of Little Traverse Bay ice showing consolidated wind swept pack ice covered with Barchan snow dunes and lakeward section of unconsolidated pancake ice.

Slide 51. Big Rock Power Plant showing small patch of open water in outfall channel and a larger refrozen ice patch indicating a more extensive previous patch of open water. Heavy shore ice right up to outfall channel.

Slide 52. Big Rock Power Plant showing same features as Slide 52.

Slide 53. Charlevoix, Michigan, showing open water channel and lakeward extensions of open water.

Slide 54. Pancake offshore lake ice north end of Grand Traverse Bay to the south of Charlevoix, Michigan.

Slide 55. Grand Traverse Bay looking south along peninsula separating East and West Bay areas.

Slide 56. Traverse City showing heavy shore ice and nearshore open water resulting from the outflow of the Boardman River.

Slide 57. Traverse City Power Plant showing open water from the plant's two discharging outfalls. Heavy ice ridges parallel to shore

THE ICE-CRUISE, 21-27 MARCH 1970

Narrative of the cruise.

The R/V MYSIS departed Grand Haven in the afternoon of March 21 to observe onshore and near offshore ice conditions in the southern part of Lake Michigan.

Small quantities of fast ice were observed north of the Grand Haven pier; a 2-4 foot high bluff remained to the south of the pier. Sand was present on the face of this bluff.

After a shakedown run off of Grand Haven the MYSIS made for Port Sheldon. Small quantities of fast ice remained immediately north of the intake pier.[1*] An ice bluff about 4 feet high containing sand was observed south of the intake pier.[2] This bluff diminished in height to the south. No ice was seen along the shore on either side of the Port Sheldon outfall.[3] Judging from the mist rising from the plume the warm water was moving to the south.[4]

The ice pattern around the Saugatuck piers was similar to that observed around the piers at Port Sheldon and Grand Haven. Small amounts of fast ice remained on the north shore and a 4-5 foot ice bluff lay south of the piers.[5] In addition to the sand present in the face of the bluff, large quantities of sand were piled on the ice inshore of the bluff.[6] Apparently this sand was deposited by waves, with sand in suspension, breaking over the bluff.

After spending the night in Saugatuck the MYSIS continued south. Several miles south of Saugatuck we encountered the first of three ice fields. The field was a few hundred yards wide and extended 2-3 miles into the lake at right angles to the shoreline.[7]

Some of the ice pieces reached 5 feet in diameter, but most were smaller, approximately 1-2 feet across.[8] Sand was observed in about 25% of the ice pieces.[9]

*Superscript numbers refer to the slide list at back.

The second ice pack was lying approximately 2 miles southwest of the South Haven piers. This field consisted of pancake ice 1-6 feet in diameter, with well developed peripheral walls.[10] The ice, starting from about one-half mile offshore, ranged to the west, then curved around to the south over a distance of approximately 2 miles. The width of the field was between 100 and 200 yards.[11] The southern boundry was sharply defined, but the northern boundry was difficult to ascertain. This was due to the gradual increase in frequency of the ice pieces from north to south.[12] A few scattered pieces of ice were found immediately south of the pack. Sand appeared in about 50% of these ice pieces.[13]

The third, and last, ice field was located around the Palisades plant site. This pack extended from the beach to about 2 miles offshore, approximately 2 miles to the north, and to the horizon in the south. This ice was loosely packed, with an average of about 25 feet between groups of closely packed ice pieces.[14] Several of these groups were about the size of a football field. Wave height outside the pack was about 2 feet. But inside the pack there were no waves, although there was a residual swell. Sand appeared in about 10% of these ice pieces.

Large irregular bluffs, perhaps as high as 8 feet in places, were seen at the Palisades plant site.[15] These bluffs contained sand, with distinct strata formed by higher densities of sand (not visible in photographs).

At the Cook plant site the ice bluff was not prominent. Several yards of tightly packed pack ice separated the bluff remnants from open water. None of the ice around the Cook plant appeared to hold much sand. However, the conditions for observation were not optimal.[16]

From the Cook site the R/V MYSIS cruised southwest to the Bailly plant. No ice was observed to the west of the plant.[17] Bluff remnants containing sand were seen to the east of the plant, separated from the outfall by several hundred yards of bare beach.[18] Several small fishing craft were in the vicinity of the plant, two of them directly adjacent to the outfall.[19]

AERIAL PHOTOGRAPHIC ICE RECONNAISSANCE SURVEY

On the 5th of March, 1970, an aerial photographic ice reconnaissance survey of the Lake Michigan shoreline was conducted using a light single-engine aircraft (Cessna 182).

Flight operations, conducted from the Ann Arbor airport, involved a total of 8 hours flight time. The survey commenced at Grand Haven, Michigan, and was flown around Lake Michigan in a clockwise direction. The flight proceeded southward along the shoreline past Michigan City and then westward to Chicago. From there the survey continued on past Milwaukee, northward along the Dorr Peninsula between Green Bay and Lake Michigan, past Manistique in the Northern Peninsula of Michigan, to a point north of Beaver Island. From this point the aircraft crossed northern Lake Michigan passing over Beaver Island on a southeasterly heading. Upon reaching the Southern Peninsula of Michigan in the area of Little Traverse Bay, the aircraft continued southward to the Traverse City airport where the aerial photographic operations were concluded.

The objective of this ice reconnaissance flight was to photograph and observe for discussion the alongshore ice and open water areas in the vicinity of specific nuclear and fossil-fuel power plants. Some of these plants were not in operation during the period of this survey. In addition various harbor areas, non-specified power plants, waste disposal plants and pollutants originating from numerous sources were observed and photographed during the flight. In all, 57 colored slides and 1 black and white slide are included with this report. The slides are displayed and discussed in the order in which the aerial survey was conducted. The geographic location and sequencial number (Slide 1 through 58) is indicated on each slide.

Along the Michigan and Indiana shores there was sufficient ice to judge the effect of plant discharges. The common observation was that shore ice extended

up to the sides of the outfall plume or channel. Some limited melt to shore in the recent past which has refrozen could be observed at the Bailey Power Plant on March 5th. Only at the Campbell plant site was there an exposure of bare beach that could be attributed to its outflow.

Except for Campbell there was no evidence that discharged waters were melting shore ice and exposing the beach to erosion. Even at Campbell there was no visible evidence of erosion even though the beach was bare.

A brief summary description and discussion of each slide is presented in Table 1.

Table 1

Slide 1. Campbell Power Plant discharge area. Open water nearshore bounded lakeward by unconsolidated pancake ice. Offshore wind direction indicated by stack smoke.

Slide 2. Campbell Power Plant area looking northward. View shows open water discharge area and ice filled harbor entrance. Shore ice present in foreground but not along melt hole.

Slide 3. Unconsolidated pancake ice offshore view of the harbor at Holland, Michigan, looking southward.

Slide 4. Entrance to harbor area at Holland, Michigan, showing open water and northward drift of water into lake through unconsolidated ice field.

Slide 5. Unconsolidated offshore drift ice in area south of Holland, Michigan.

Slide 6. Open water channel and harbor at Fennville, Michigan.

Slide 7. Open water channel and harbor at South Haven, Michigan.

Slide 8. Pallisades Power Plant showing open water in discharge channel and adjacent lake area. Stack smoke indicates onshore breeze from the northeast. Shore ice up to flume sides.

Slide 9. Pallisades Power Plant discharge area and offshore ice field. View looking southeastward shows open water areas and wind direction.

Slide 10. Alongshore ice, built up from spray and onshore water and ice movement. South of Pallisades plant area near South Haven, Michigan.

Slide 11. Benton Harbor, Michigan, showing open water in entrance channel and alongshore to the south, produced by river flow deflecting the ice.

Slide 12. Harbor channel at Benton Harbor, Michigan. Open water in channel and nearshore area to the south.

Slide 13. Cook Power Plant looking north. Some open water alongshore next to plant site from construction pumps and water runoff.

Slide 14. Unaffected shore ice, ridge and pancake ice south of Cook plant near New Buffalo, Michigan.

Slide 15. Michigan City Power Plant. Open water in channel. Ice moving around breakwater toward south. Strong wind from the northeast moving smoke parallel to shore.

Slide 16. Michigan City Power Plant channel outlet showing open water. Note heavy shore ice between outfall and breakwater.

Slide 17. Bailey Power Plant outfall and crib showing small patch of open water at outlet in pancake ice. Heavy shore ice in immediate vicinity of outfall flume.

Slide 18. Bailey Power Plant outfall photographed on 19 January 1970. Warm water has produced elongate patch of open water toward the east as a result of west wind indicated by shadow of stack smoke. Temperature differential between water and air producing evaporation is indicated by vapor near water surface. Shore ice out to well beyond the beach groins. Photo by courtesy of NIPSCO.

Slide 19. Air pollution from steel mill operations at Gary, Indiana.

Slide 20. River water discharge as indicated by color differential between channel water and lake water. Steel mill operations at Gary, Ind.

Slide 21. Water color contact between channel discharge and lake. Steel mill operations at Gary, Ind.

Slide 22. Waukegan Power Plant outfall and intake area looking north. Water circulation patterns are indicated from movement of unconsolidated pancake ice.

Slide 23. Waukegan Power Plant outfall and intake. Intake channel shows ice accumulation while outfall is ice free. Circulation pattern of discharged water is indicated by distribution of pancake ice.

Slide 24. Waukegan Power Plant outfall and intake. Shows same characteristics as Slide 23.

Slide 25. Zion Power Plant shows movement of ice from north to south around breakwater.

Slide 26. Zion Power Plant. Closer view of outfall area than shown in Slide 25.

Slide 27. Kenosha, Wisc., Waste Disposal Plant and offshore discharge area.

Slide 28. Racine, Wisc., Shoreline Industry and the resulting influence on the coloration of nearshore lake water.

Slide 29. Oak Creek Power Plant showing ice filled intake channel and open water at outfall. Movement of coal dust into the intake channel resulting from north wind movements can be observed on the ice surface.

Slide 30. Lakeside Power Plant. Pancake ice around intake area.

Slide 31. Port Washington Power Plant. River discharge into harbor area and southward movement of brown river water into lake.

Slide 32. Shore ice build-up to south of Sheboygan, Wisc.

Slide 33. Sheboygan Power Plant. Nearshore open water with lakeward accumulations of pancake ice.

Slide 34. Sheboygan Power Plant looking northward. Onshore breeze is indicated by smoke. Offshore water circulation patterns are indicated by pancake ice.

Slide 35. Sheboygan, Wisc., showing river discharge into harbor area and movement of pancake ice to the south around the breakwater.

Slide 36. Field of pancake ice near Sheboygan, Wisc.

Slide 37. Manitowoc, Wisc., showing waste disposal plant offshore discharge area and ice filled harbor area.

Slide 38. Two Rivers, Wisc., showing channel and river water projecting into the lake.

Slide 39. Point Beach Power Plant showing the outfall channels projecting into nearshore ice. Offshore crib is ice free.

Slide 40. Kewaunee Power Plant and nearshore ice.

Slide 41. Washington Island at the tip of the Dorr Peninsula showing ice covered Green Bay to the west (left) and nearshore accumulations of ice.

Slide 42. Ice covered Green Bay as seen from the islands extending north of the Dorr Peninsula, Wisc.

Slide 43. Ice covered Green Bay looking west from Fairport, Mich. (Pt. Detour).

Slide 44. Shore ice and reconsolidated offshore pack ice and leads. To the north of Pt. Detour, Mich.

Slide 45. Shore ice and wind swept offshore ice covered with Barchan type snow dunes indicating a relatively steady wind from the north. Shoreline between Pt. Detour and Manistique, Mich.